DESIGN OF MICROCONTROLLER BASED TEMPERATURE CONTROLLER

A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

Bachelor of Technology
In
Electronics and Instrumentation Engineering

by

MANISH MISHRA

Roll No. 109EI0075

Department of Electronics & Communication Engineering
National Institute of Technology, Rourkela

2013

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Under the guidance
of
Prof. Munshi Nurul Islam

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National Institute of Technology, Rourkela

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DECLARATION

We hereby declare that the project work entitled **“DESIGN OF MICROCONTROLLER BASEDTEMPERATURE CONTROLLER”** is a record of our original work done under Prof. Munshi Nurul Islam, National Institute of Technology, Rourkela. Throughout this project wherever contributions of others are involved, every endeavor has been made to acknowledge this clearly with due reference to literature. This project work is being submitted in the partial fulfillment of the requirements for the degree of Bachelor of Technology in Electronics and Instrumentation Engineering at National Institute of Technology, Rourkela for the academic session 2009– 2013**.**

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA

CERTIFICATE

This is to certify that the thesis entitled "**DESIGN OF MICROCONTROLLER BASED TEMPERATURE CONTROLLER**", submitted by Mr. MANISH MISHRA (109EI0075) for the Award of Bachelor of Technology Degree in 'ELECTRONICS &INSTRUMENTATION' Engineering at the National Institute of Technology(NIT), Rourkela is an authentic work carried out by him under my supervision.

Date: 13th May,2013

Prof. Munshi Nurul Islam

Department of Electronics and Communication Engineering

National Institute of Technology, Rourkela-769008

ACKNOWLEDGEMENT

I would like to express my gratitude and sincere thanks to my respected supervisor Prof. Munshi Nurul Islam for the guidance and support that he has provided throughout the course of this work. This work would never have been possible without his vital inputs and mentoring.

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MANISH MISHRA

(109EI0075)

ABSTRACT

The "MICROCONTROLLER BASED TEMPERATURE CONTROLLER "controls the temperature of any device according to its requirement for any industrial application. At the heart of the circuit is the ATMEGA32 microcontroller which controls all its functions. A temperature sensor LM35 is used for sensing the temperature of the environment and the system displays the temperature on an LCD in the range of –55°C to +150°C.This temperature is compared with the value stored by the user and if the temperature goes beyond the preset temperature then heater will switch off and if temperature goes below to preset value then heater will switch on. AC bulb is interfaced with the microcontroller which is done with the help of a relay and an npn transistor.

Keywords: Temperature, LM35, ATmega32, microcontroller, LCD, Relay etc.

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Chapter 01

INTRODUCTION

1.1 Introduction:-

Temperature is one of the main parameter to control in most of the manufacturing industries like chemical, food processing, pharmaceutical etc. In these kinds of industries some product need the required temperature to be maintained at highest priority the product will fail. So the temperature controller is most widely used in almost all the industries.

The goal of this project is to design an ambient temperature measurement and control circuit. The motivation for the project is the fact that temperature measurement has become an integral part of any control system operating in a temperature sensitive environment and the various learning outcomes associated during the implementation of the project.

It is basically a close loop control system. There are two types: ON-OFF type or continuous type system.

ON-OFF type- Temperature is sensed, displayed and it is compared with set value. If it is greater, then it switches off the heating element and if it is less, then switches on the heating element.

Continuous type- Temperature is sensed, displayed and it is compared with set value. If it is greater/less, then control the heat produced by heating element by changing its supply current.

In this project ON-OFF type controller has been implemented. Here the set value for temperature can be externally set by the user. The actual temperature is sensed by the temperature sensor. It is displayed on LCD with the set value. If it exceeds the set value the heater is turned off. After then when temperature falls below the specified limit again heater is turned on.

Chapter-02

LITERATURE REVIEW

2.1 HARDWARE REQUIREMENTS:-

1. LM 35 temperature sensor
2. ADC
3. Microcontroller(ATmega32)
4. LCD(16x2)
5. Relay
6. Heater
7. Transistor
8. Resistors
9. AC Supply

2.2 LM35 TEMPERATURE SENSOR:-

The LM35 series are precision integrated-circuit temperaturesensors.Their output voltage is linearly proportional to theCelsius temperature. The LM35 thus has a benefit over linear temperature sensors calibrated in° K, as there is no need to subtract a large constant voltage from its output to obtain Centigradereading. It does not require any externalcalibration or trimming to provide typical accuracies of ±1⁄4°Cat room temperature and ±3⁄4°C over a full −55 to +150°Ctemperature range. Low cost is due to trimming andcalibration at the wafer level. The LM35'slinear output, and precise inherent calibration makeinterfacing to readout or control circuitry especially easy. LM35can be used with single power supplies, or with plus andminus supplies.It draws only 60 µA from its supply, so it hasvery low self-heating, less than 0.1°C in still air. It israted to operate over a −55° to +150°C temperature range,while the LM35C is rated for a −40° to +110°C range (−10°with improved accuracy).

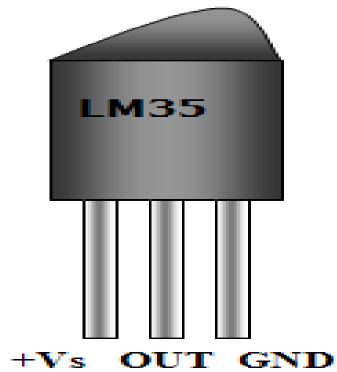


Figure 2.1: LM35 Pin Configuration

The +Vs can be from 4V to 20V as specified by the pin configuration. To use the sensor Vcc was connected to +5V, GND to ground and the OUT to one of the ADC (analog to digital converter channel). The output varies linearly with temperature. The output is 10 mill volts per degree centigrade.

2.3 ADC:-

In LM35 temperature sensor the output voltage varies according to the temperature, so if we could measure the voltage, we can measure the temperature.Microcontrollers are digital in nature. Only high and low level on input pins can be differentiated by them.For example if input is more than 2.5V it will be taken as 1 and if it is below 2.5 it will be taken as 0. So we cannot measure voltage directly from microcontrollers. To solve this problem modern microcontrollers have an inbuilt ADC unit. ADC will convert a voltage to a number so that it can be processed by a digital system like microcontroller.

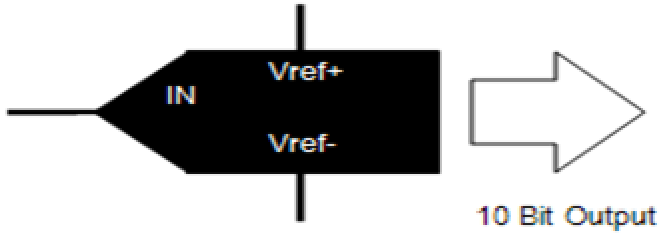


Figure2.2: ADC

This enables us to easily interface all sort of analog devices with microcontrollers. Temperature sensor is one of the examples of analog devices.

Specifications of ADCs:

Most important application of ADCs is the resolution. This specifies how accurately the a ADC measures the analog input signals. Common ADCs are 8bit, 10bit and 12bit. For example if the reference voltage of ADC is 0 to 5v then 8 bit ADC will break the range in 256 divisions so it can measure it accurately up to 5/255v=19mv approx. while the 10 bit ADC will break the range in 5/1024=4.8mv approx. so we can see that the 8 bit adccannot tell the difference between 1mv and 18mv. The adc in ATmega32 is 10 bit.

2.4 ATMEGA32:-

ATmega32 is an 8-bit high performance microcontroller. It is a less power consuming device. The Atmel's ATmega series of microcontrollers are very popular due to the large number of peripherals built in them. They have features such as 10-bit A/D converters, UART/USART, and much more and due to that reason they become useful for a large number of applications and external hardware is reduced as these are built-in.

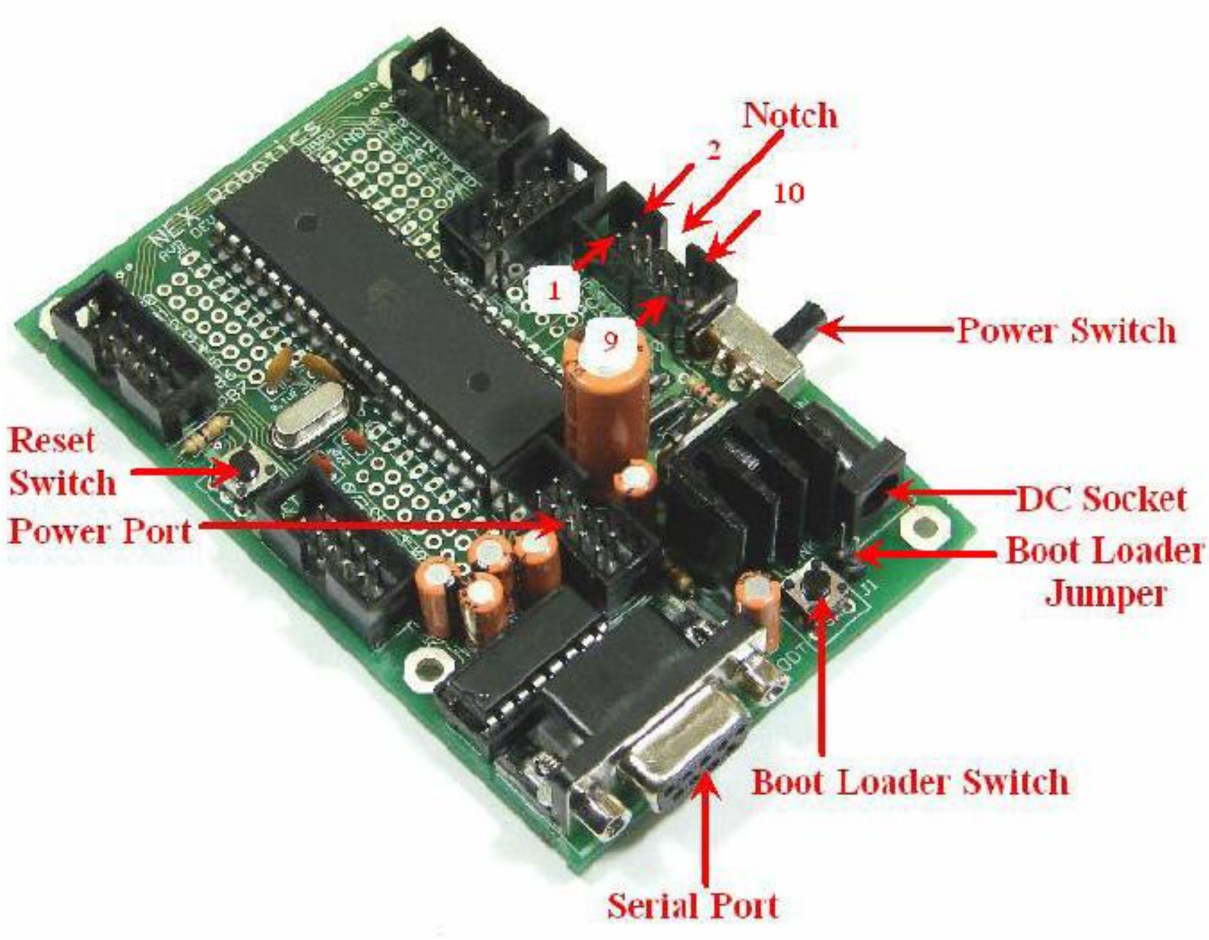


Figure 2.3: ATmega32 Development Board

Features:

• High-performance, Low-power 8-bit Microcontroller

• Advanced RISC Architecture

– 131 Powerful Instructions

– 256 General Purpose Working Registers

– Fully Static Operation

– Up to 16 MIPS Throughput at 16MHz

– On-chip 2-cycle Multiplier

• Non-volatile Memory segments

– 32Kbytes of Self-programmable Flash program memory

– 1024Bytes EEPROM

– 2Kbytes Internal SRAM

– Write/Erase Cycles

– Data retention:100 years at 25°C

True Read-While-Write Operation

• JTAG (IEEE std. 1149.1 Compliant) Interface

– Boundary-scan Capabilities

– Extensive On-chip Debug Support

– Programming of Flash, EEPROM

• Peripheral Features

– Two 8-bit Timer/Counters

– One 16-bit Timer/Counter

Mode

– Four PWM Channels

– 8-channel, 10-bit ADC

8 Single-ended Channels

2 Differential Channels with different Programmable Gain

– Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– On-chip Analog Comparator

• Special Microcontroller Features

– Power-on Reset

– Internal Calibrated RC Oscillator

– Six Sleep Modes

• I/O and Packages

– 32 Programmable I/O Lines

– 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF

• Operating Voltages

– 2.7V - 5.5V for ATmega32L

– 4.5V - 5.5V for ATmega32

• Speed Grades

– 0 - 8MHz for ATmega32L

– 0 - 16MHz for ATmega32

• Power Consumption at 1MHz, 3V, 25°C

– Active: 1.1mA

– Idle Mode: 0.35mA

– Power-down Mode: < 1µA

Pin Configurations of ATmega32

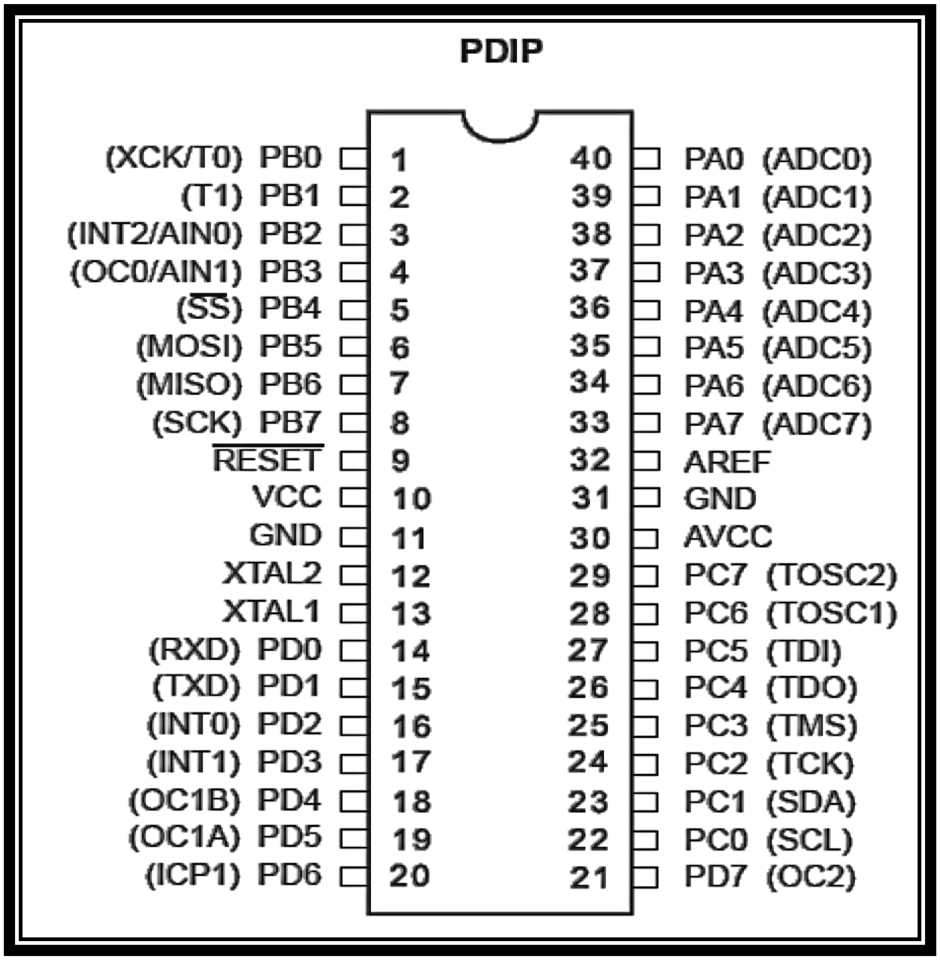


Figure 2.4: ATmega32 Pin Configuration

Pin Description:

VCC: Digital supply voltage.

GND: Ground.

Port A (PA7..PA0): Port A serves as the analog inputs to the A/D Converter. Port A is also used as an 8-bit bi-directional I/O port if the analog to digital converter is not used. The Port A output buffers have symmetrical drive characteristics. When pins PA0 to PA7 are used as inputs, they will source current if the internal pull-up resistors are activated. When a reset condition becomes active, Port A pins are tri-stated even if the clock is not running.

Port B (PB7..PB0): Port B is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port B output buffers also have symmetrical drive characteristics with both high sink and source capability. Port B pins which are externally pulled low will source current if the pull-up resistors are activated. When a reset condition becomes active and even if the clock is not running, the Port B pins becomes tri-stated.

Port C (PC7..PC0) Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). If the pull-up resistors are activated Port C output buffers also have symmetrical drive characteristics with both high sink and source capability. Port C pins which are externally pulled low will source current. When a reset condition becomes active the Port C pins are tri-stated, even if the clock is not running. The pull-up resistors on pinsPC5 (TDI), PC3 (TMS) and PC2(TCK) will be activated if the JTAG interface is enabled even if a reset occurs.

Port D (PD7..PD0) Port D is an 8-bit bi-directional I/O port with internal pull-up resistors. The Port D output buffers also have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins which are externally pulled low will source current if the pull-up resistors are activated. When a reset condition becomes active the Port D pins becomes tri-stated, even if the clock is not running.

RESET: Reset Input. A reset is generated if a low level occurs on this pin for longer than the minimum pulse length , even if the clock is not running. Shorter pulses will generate a reset it is not guaranteed.

XTAL1 It is the input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2 It is the output coming from the inverting Oscillator amplifier.

AVCC: It is the supply voltage pin for Port A and for the A/D Converter. Even if the ADC is not used it must be externally connected to VCC. If the ADC is used, it is connected to VCC with the help of a low-pass filter.

AREF: It is the analog reference pin for the ADC.

2.5 LIQUID CRYSTAL DISPLAY (LCD):-

Description:

LCD (Liquid Crystal Display) is an electronic display system. A 16x2 LCD display is a very basic system and commonly used in various devices and circuits. LCD's are preferred over seven segments and other multi segment LEDs. The advantages of LCD's are as follows:

- LCDs are economical.
- They are easily programmable.
- A number of characters can be displayed.
- Very compact and light.
- Low power consumption.

A 16x2 LCD means it can display 16 characters per line and 2 such lines are there. In this LCD every character is displayed in 5x7 pixel matrix. LCD possesses two registers: Data and Command registers. The command register stores the command instructions given to the LCD. A command can be defined as an instruction given to LCD to do a predefined task. For example, initializing the LCD, clearing the screen, controlling the cursor position, controlling the display etc. The data register stores the data which is displayed on the LCD screen. The data is the ASCII value of the character which is displayed on the LCD screen.

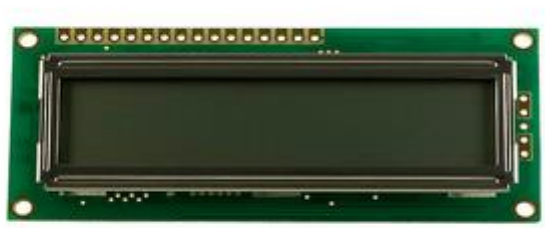


Figure 2.5: 2×16 LCD DISPLAY

PIN DIAGRAM

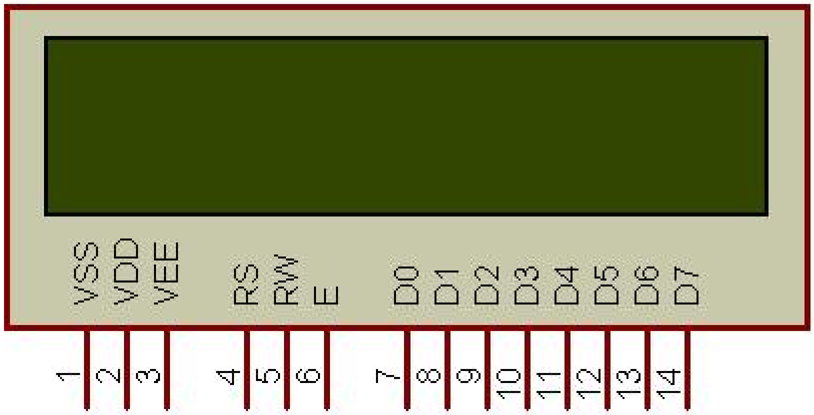


Figure 2.6: LCD Pin Diagram

Pin Descriptions:

PIN NO.	NAME	FUNCTION
1	Ground	Ground (0V)
2	Vcc	Supply voltage: 5V
3	V_{EE}	Contrast adjustment; through a variable resistor
4	Register Select(RS)	Selects commandregister when low; and data register when high
5	Read/write(RW)	Low to write to the register; High to read from the register
6	Enable(EN)	Sends data to data pins when a high to low pulse is given
7	DB0	8-bit data pins
8	DB1	
9	DB2	
10	DB3	
11	DB4	
12	DB5	
13	DB6	
14	DB7	

PROGRAMMING OF LCD:

For programming the 16x2 LCD display there are three basic steps .

- Initialization of LCD
- Giving command for reading the given data.
- Giving command for writing data and displaying on the screen

LCD COMMANDS:

CODE(HEX)	COMMAND TO LCD
1	Clear display Screen
2	Return home
4	Decrement cursor (shift cursor to left)
6	Increment cursor (shift cursor to right)
5	Shift display right
7	Shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor blinking
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Bring the entire display to the left
1C	Bring the entire display to the right
80	Bring cursor to beginning of 1st line
C0	Bring cursor to beginning of 2nd line

2.6 TRANSISTOR (BC547):-

TECHNICAL SP2ECIFICATIONS:

The BC547 transistor is an NPN Transistor. The BC547 transistor is a general-purpose transistor. It is used in general-purpose switching and amplification .

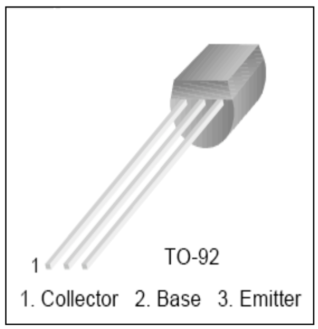


Figure 2.7: BC 547 Transistor pin configuration

Transistor is a "CURRENT" operated device and a large current (Ic) flows through the device between the collector and the emitter terminals. But, this only happens when a small biasing current (Ib) is flowing into the base terminal of the transistor thus allowing the base to act as a sort of current control input. The ratio of the two currents (Ic/Ib) is called the DC Current Gain of the device and is given the symbol of Beta, (β). Beta has no units as it is a ratio. The ratio of the emitter to the collector current, Ic/Ie, is called Alpha, (α). As the emitter current Ie is the product of a very small base current to a very large collector current, the value of the α is very close to unity, and this value is found to be about 0.950 to 0.999for a typical low-power signal transistor.

An NPN Transistor Configuration

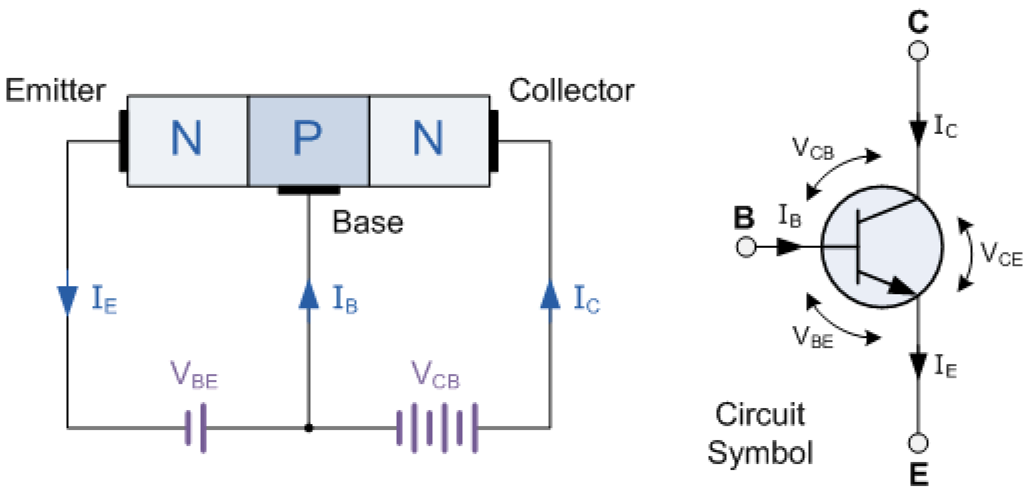


Figure 2.8 NPN Transistor Configuration

BRIEF DESCRIPTION OF TRANSISOR ACTING AS SWITCH

An NPN transistor is "on" when its base is pulled high relative to the emitter. when the device is in forward active mode the arrow in the NPN transistor symbol is on the emitter leg and points in the direction of the conventional current flow. Whenever base is high, then current starts flowing through base and emitter and after that only current will pass from collector to emitter.

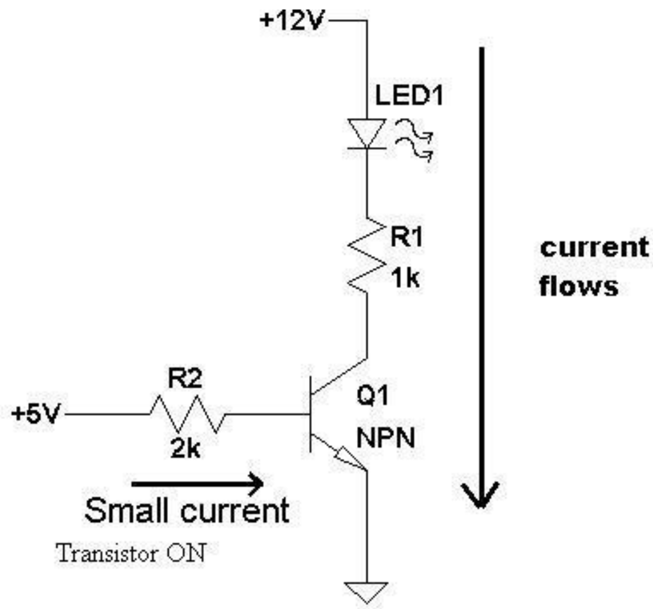
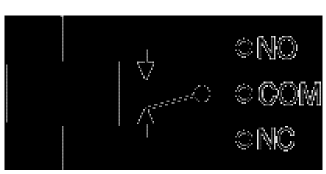


FIGURE 2.9: Transistor as a switch

2.7 RELAY:-

A relay is a switch whose operation depends on the electricity. A switching mechanism is operated mechanically within the relays with the use of an electromagnet,. Relays are used when it is necessary to control a circuit by a low-power signal , or where several circuits must be controlled by one signal.



Current flowing through the coil of the relay creates a magnetic field which attracts a lever and switch contacts are changed. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram.

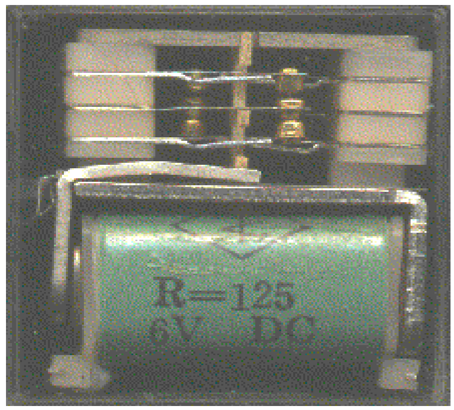


Fig 2.10 Relay showing coil and switch contacts

Relays allow one circuit to switch a second circuit. A low voltage battery circuit can use a relay to switch a 230V AC mains circuit. Inside the relay between the two circuitsthere is no electrical connection; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, approximately 30mA for a 12V relay, but it can be upto 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value which isrequired for the relay coil. The maximum output current for ther 555 timer IC is 200mA so these devices can supply relay coils directly without anyamplification.

Relays are of two types: normally open or normally closed.in normally open relays switch remains open until energized (ON) while in normally closed relays switch is closed until energized. Relays are shown in de energized position i.e when there is no current in the control circuit.

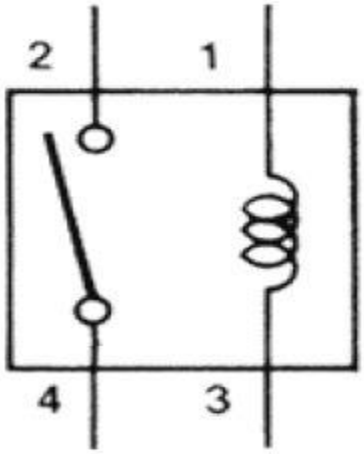


Figure 2.11: Normally Open (NO) switch

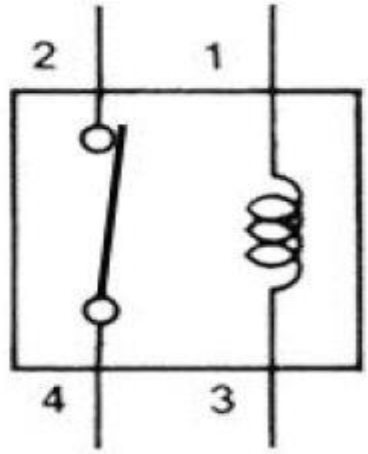


figure 2.12: Normally Closed (NC) switch

A relay with its coil and switch contacts is shown in the fig. A lever on the left being attracted by magnetism when the coil is switched on. That lever moves the switch contacts.

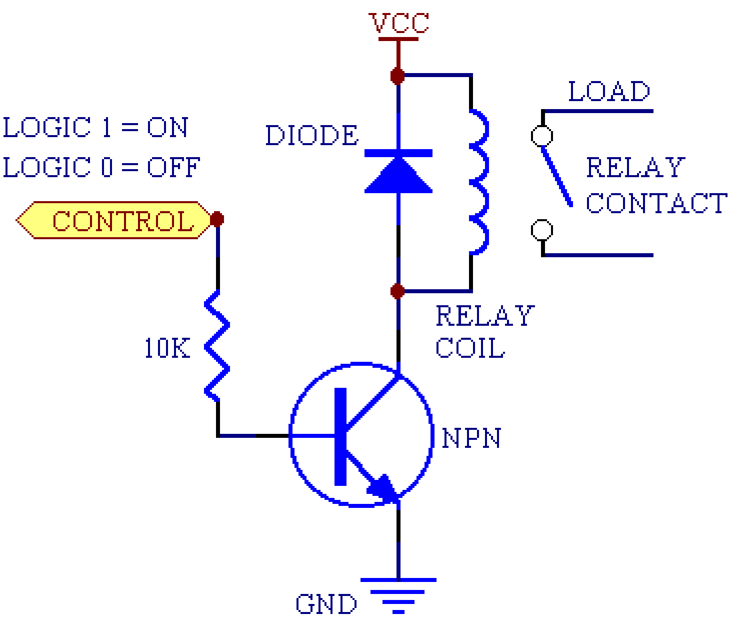


Figure 2.13: Relay Circuit

The switch connections of the relays are usually:

- COM = Common, always connect to this; it is the moving part of the switch.
- NC = Normally Closed, COM is connected to this when the relay coil is off.
- NO = Normally Open, COM is connected to this when the relay coil is on.

Chapter-3

SOFTWARE AND CODE

3.1 Introduction:-

The following software's were used for programming and feeding in ATmega32 microcontroller.

1.AVR Studio 4 : AVR Studio 4 is the development platform. AVR studio is required to write the C-code and generate its HEX code.

2.Win AVR: It is used to compile the program.

3.Sinaprog 2.0 : It is used to burn the program and hex file is dumped into the microcontroller.

3.2 Starting AVR Studio 4 and Creating a Project:-

1. Open the AVR Studio.
2. Click on the New Project button.

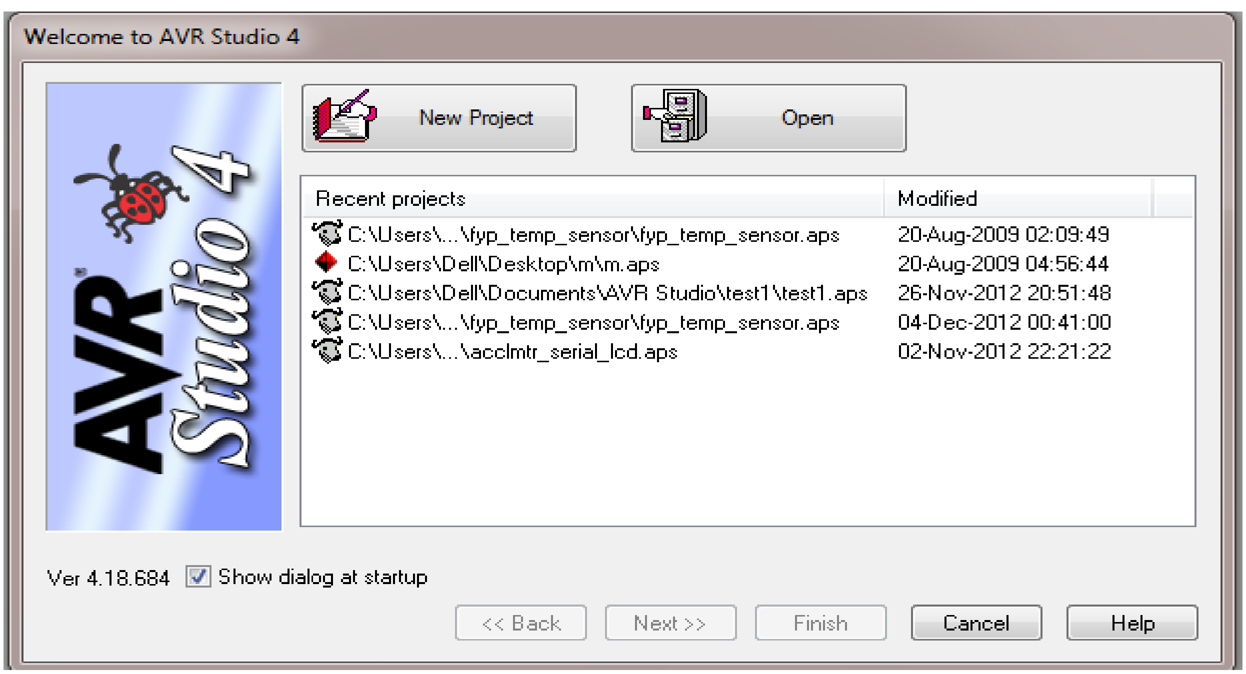


Figure 3.1: Welcome window

3. Do the followings:

- In the left side, select AVR GCC.
- Choose the name for the project.
- Choose the location where the files of the project will be saved.
- Press the next button.

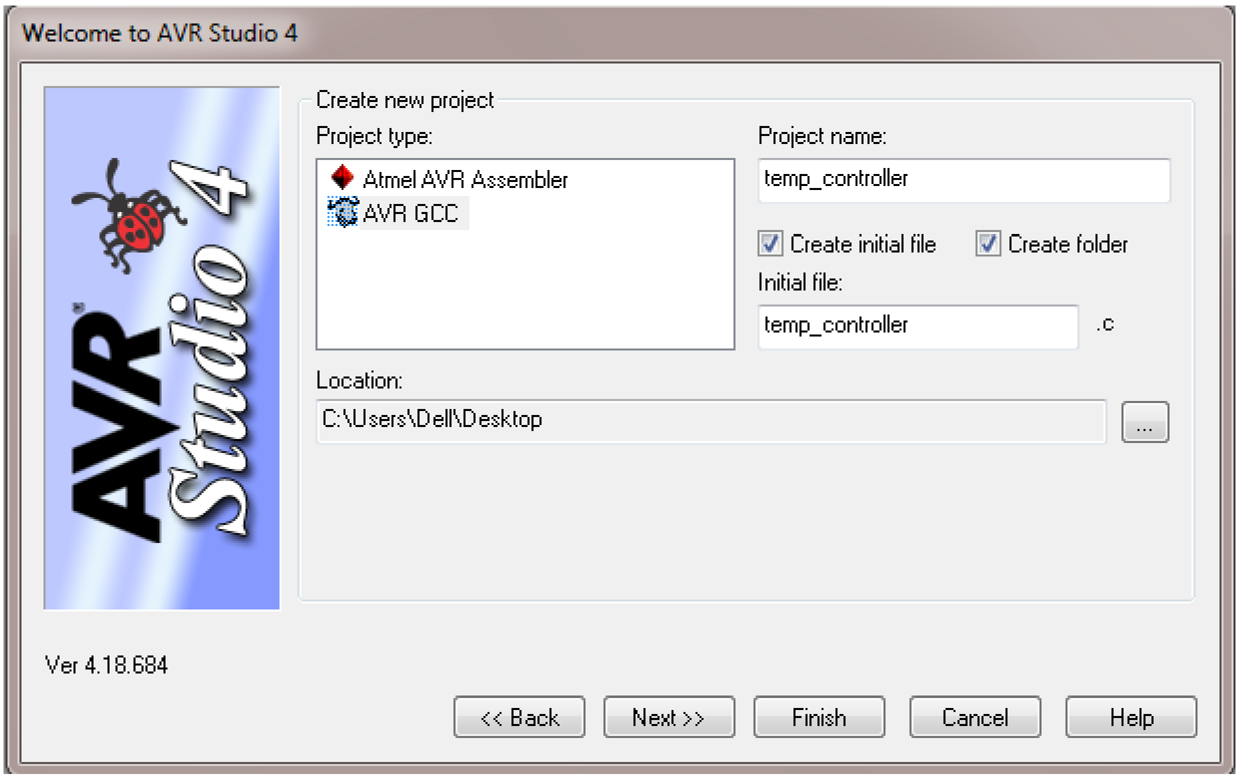


Figure 3.2: Name the project

4. Choose AVR Simulator from left side and ATmega32 from the right side and press Finish button.

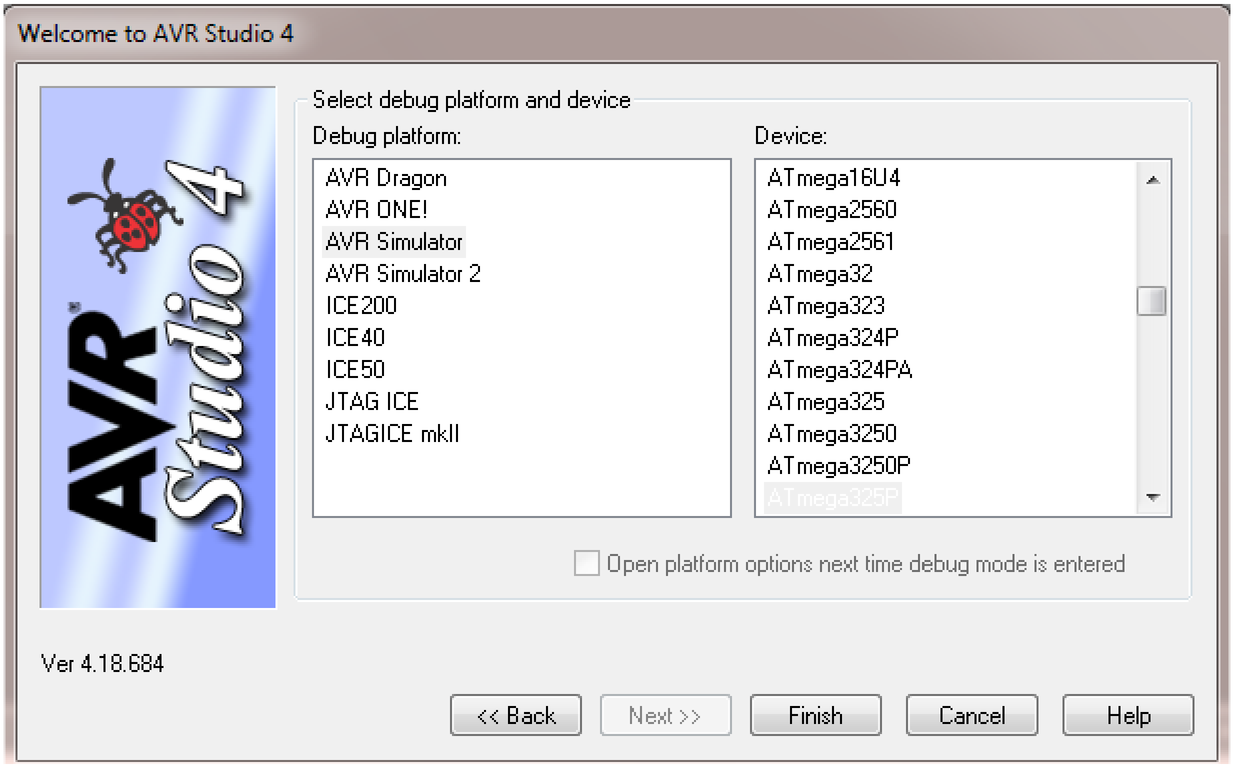


Figure3.3: Choosing the microcontroller

5. Write the program.

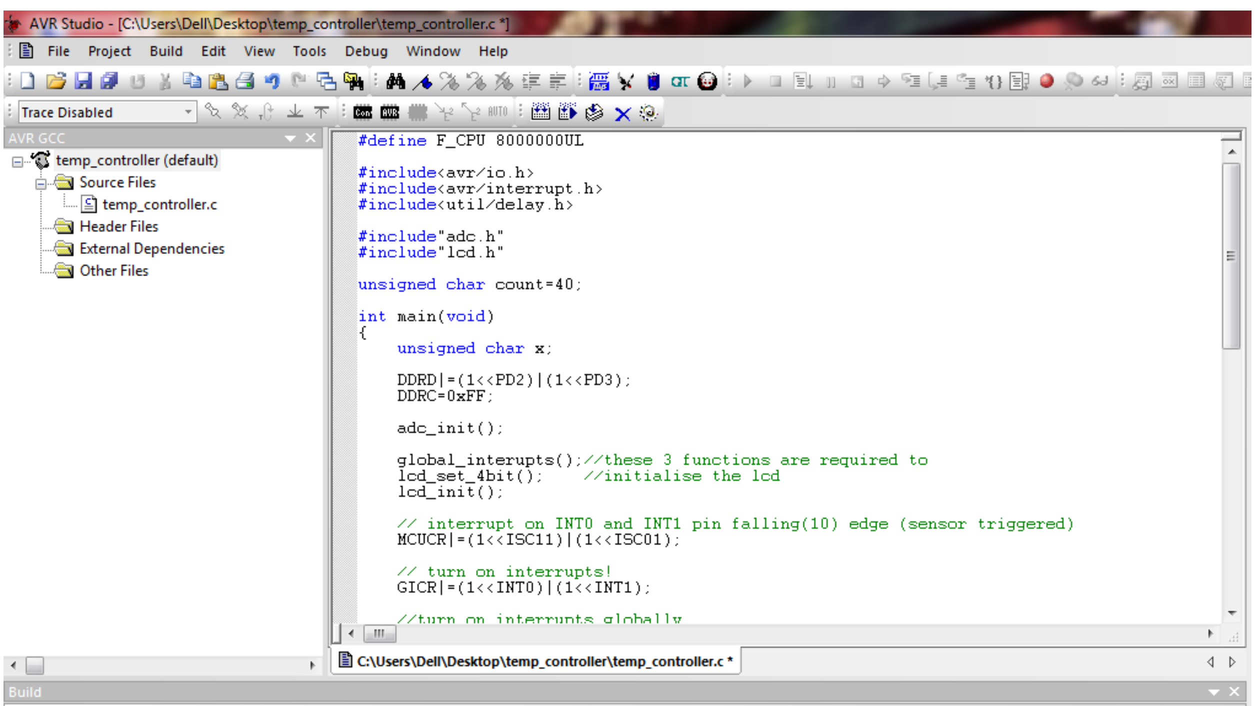


Figure3.4: Writing the program

6. Save the program .
7. Select Build for compiling the program.

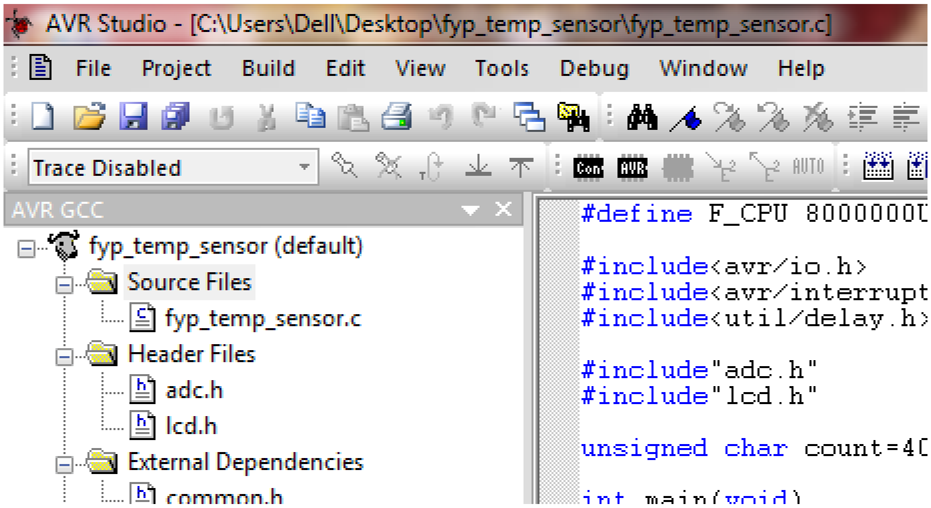


Figure3.5 :Building the program

8. Correct the errors.

3.3 Burning the code using Sinaprog Software:-

The hex file is generated with same name as program using WinAvr. This program is transferred to flash memory of microcontroller. An USB ISB programmer can be used to burn the program. Through the sinaprog software the program is burnt into microcontroller. The burner uses SPF port of microcontroller to load the program.

Steps :

1 Hex file is generated.

2 Connect the ATmega32 development board and PC through burner

3 Open sinaprog and select ATmega32.

4 Load the program and burn through sinaprog.

5 Output is shown.

3.4 Source Code:-

```
#define F_CPU 8000000UL

#include<avr/io.h>

#include<avr/interrupt.h>

#include<util/delay.h>

#include"adc.h"

#include"lcd.h"

unsigned char count=40;

int main(void)

{

  unsigned char x;

DDRD|=(1<<PD2)|(1<<PD3);

  DDRC=0xFF;


  adc_init();

  global_interupts();//these 3 functions are required to

  lcd_set_4bit();    //initialise the lcd

  lcd_init();

// interrupt on INT0 and INT1 pin falling(10) edge (sensor triggered)

  MCUCR|=(1<<ISC11)|(1<<ISC01);

// turn on interrupts!
```

```
  GICR|=(1<<INT0)|(1<<INT1);

  //turn on interrupts globally

  sei();

while(1)

  {

        x=read_adc_channel(0);lcd_string("Current_Temp ");

        lcd_adc_value(2*x);

        //lcd_string(" C");

        lcd_cursor (2,1);

        lcd_string("Max_Temp ");

        lcd_adc_value(count);

        lcd_home();


        if(x>count)

        {

              PORTC=0x01;

        }

if(x<count)

        {

              PORTC=0x00;

        }

  }

}
```

```
ISR(INT0_vect)
{
  count++;
  //_delay_ms(5);
}
ISR(INT1_vect)
{
  count--;
  //_delay_ms(5);
}
```

Chapter-04

SYSTEM DESIGNING & IMPLEMENTATION

4.1 Hardware Block Diagram:-

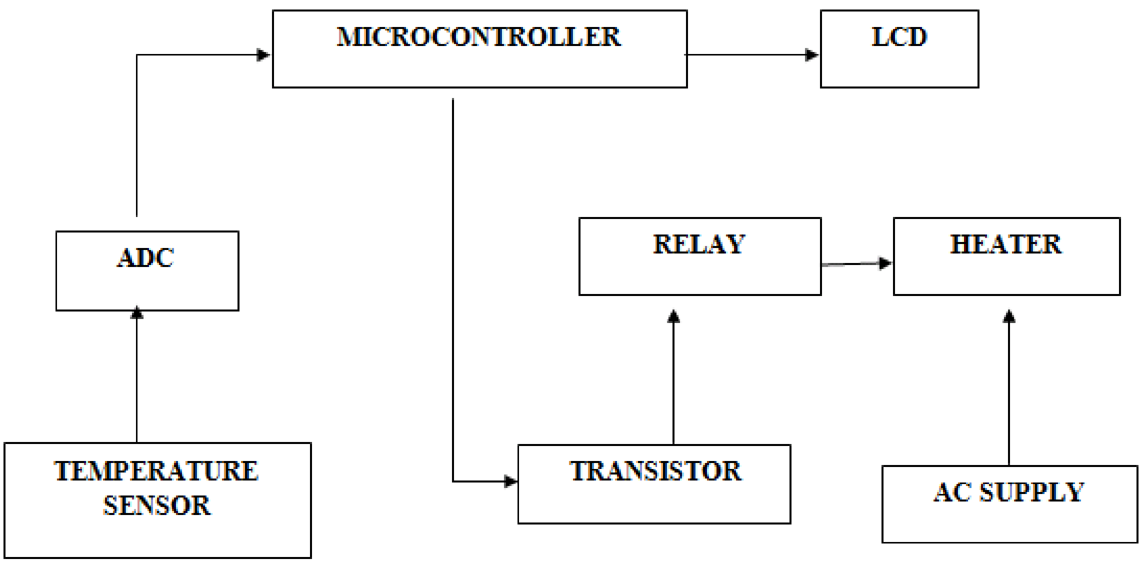


Figure 4.1: Hardware Block Diagram

4.2 IMPLEMENTATION:-

1.The output pin of LM35 temperature sensor was connected to one of the ADC input pin of ATmega32 microcontroller.

2. LCD was connected to Port C of the microcontroller.

3. ADC was activated for interfacing the temperature sensor and a program wais written so that whatever temperature the sensor sense it can be displayed on LCD screen.

4. A nomally closed relay was interfaced to Port B of the ATmega32 with the help of transistor to turn off the heater when temperature is above the set point. Transistor was acting as a switch to turn ON/OFF the relay.

5. An AC bulb was interfaced with the microcontroller with the help of relay.

6. Reset switches were connected to PORT D so that user can set the temperature of the device accordingly.

7. Code was written such that the microcontroller can switch ON/OFF bulb with respect to set temperature.

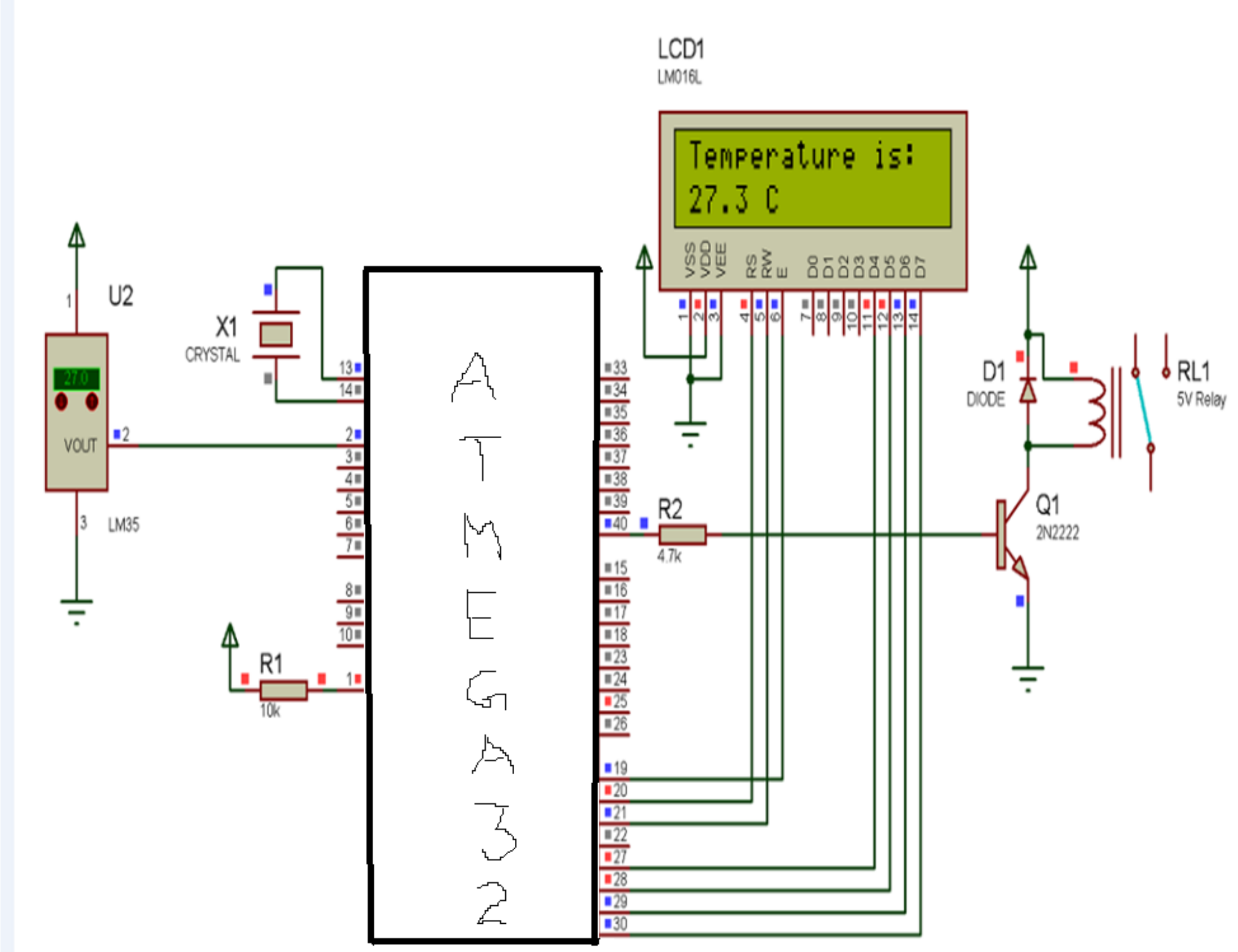


Figure 4.2: Schematic Diagram

4.3 WORKING:-

The project uses a precision centigrade temperature sensor LM35 which is capable of sensing the temperature. It gives the output in millivolts. This output is converted into corresponding digital data using inbuilt ADC of the ATmega32 microcontroller. LCD is interfaced with the microcontroller & the value of the actual temperature is displayed on the LCD.

The LCD displays the present temperature as well as set temperature. The set value can be increased through switches attached to the microcontroller. If the temperature crosses the maximum value the heater is switched off as indicated by a bulb connected through a relay driven by a transistor connected to the microcontroller. If the temperature goes below the set value the heater is on.

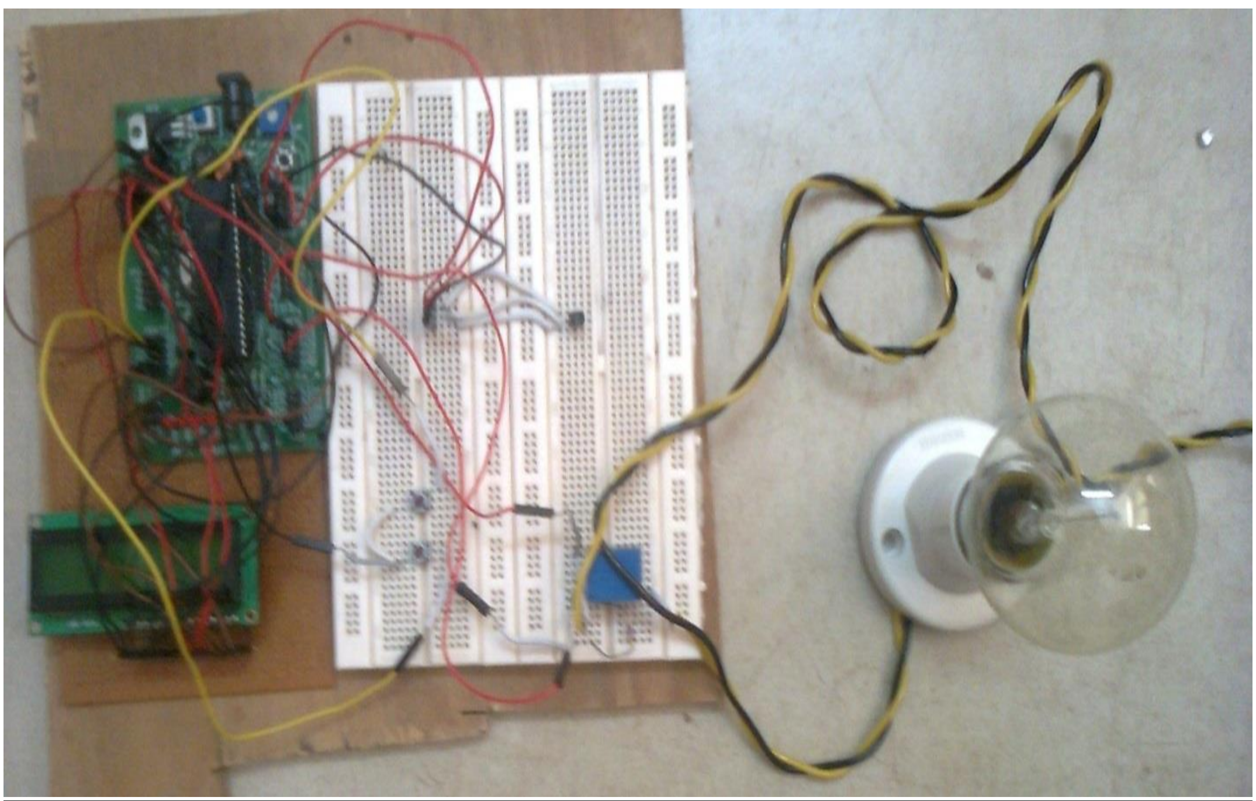


Figure 4.3: Final Setup of the project

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RESULTS AND CONCLUSIONS

5.1 RESULTS AND CONCLUSION:-

Microcontroller based temperature controller is a simple and useful circuit which can be used to control the temperature above a set value using LM35 temperature sensor.

.Initially, circuit was selected and components where purchased and the circuit was verified in bread board. Then we designed the PCB and the circuit was soldered onto the PCB.

The actual temperature and set value of temperature were getting displayed on the LCD screen and the set temperature was found changing with the help of preset buttons.

Output was verified by setting the temperature at different levels and it was found that the heater (bulb) turn on and off when the device crosses the set value.

5.2 FUTURE SCOPE AND ENHANCEMENTS:-

Microcontroller based temperature controller is a simple whereas a useful circuit with which the temperature can be controlled with the aid of a LM 35 temperature sensor. As explained the circuit can be made useful in practical area where the circuit can be connected to a device whose temperature has to be controlled at a particular limit say a water tank with a heater whose temperature can be set to a particular value. Similar another application is that the circuit attached with a buzzer which can be connected to a device like an iron box so that it would help to save electricity by avoiding overheating of the device.

In future the circuit can be enhanced by connecting a GSM Module to the circuit so that in industrial area when a machine crosses the set temperature, we can inform the control room by sending a message, or else a call to control room manager so that damages to the machine can be avoided by disconnecting the equipment with GSM technology.

Chapter-06

REFERENCES

6.1. REFERENCES

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